EVALUATION OF REINTRODUCTION OF YOUNG OF YEAR COLORADO PIKEMINNOW IN THE SAN JUAN RIVER: 1999 ANNUAL REPORT

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INTRODUCTION

Colorado pikeminnow (*Ptychocheilus lucius*) reproduction was documented in five of the seven years of the San Juan Recovery Implementation Program (RIP) research project (1991-1997) under a variety of flow regimes. However, recruitment into the adult population was, and is, very limited. From 1991 to 1996, only 41 age 0 and larval Colorado pikeminnow have been captured during backwater and drift sampling (Holden and Masslich 1997).

The low levels of recruitment experienced by Colorado pikeminnow in the San Juan River have initiated further study into the mechanisms limiting age 0 success. Three hypotheses have emerged: 1) recruitment is limited by insufficient numbers of spawning adults and other factors limiting spawning, 2) the spatial and temporal dynamics of backwater (nursery) habitats prevent the retention of Colorado pikeminnow within the system and 3) interspecific competition between Colorado pikeminnow and non-native species for space and limited food resources limits survival of age 0 pikeminnow.

Because natural reproduction is so low, habitat limitations and use by Colorado pikeminnow could not be properly addressed. Therefore the decision was made to stock young-of-year Colorado pikeminnow in the San Juan River in order to evaluate A) survival, growth, and retention, and B) habitat availability and use. The original study plan called for Colorado pikeminnow to be stocked in 1996 and 1997, and was later expanded to include stocking in 1998, 1999 and 2000 as well.

Approximately 100,000 Colorado pikeminnow were stocked at Shiprock NM, and at Mexican Hat, UT, in November 1996 and again in August 1997, and a further 10,571 were stocked at Shiprock in July 1998. Chapter 4 *in* Archer et al. (2000), provided an evaluation of stocked young-of-year Colorado pikeminnow from 1996 to 1998, including growth, distribution, retention, and an analysis of habitat availability and use by Colorado pikeminnow. The stocked fish exhibited excellent growth rates, comparable to or exceeding those seen in wild pikeminnow in the Green and Colorado rivers. The initial recapture rate was 0.3-0.5% of the stocked fish. Catch rates declined steadily thereafter. At age-1 (55-120 mm) the fish underwent a shift in habitat use away from backwaters, where they began being collected during Fish and Wildlife Service (FWS) electrofishing efforts (Ryden 2000). Although initial survival was low, survival from age-1 to age-2 appeared to be essentially 100%, as they continued to be collected by the FWS. Nursery habitat did not appear to be limiting the growth and survival of young Colorado pikeminnow.

The study initially called for stocking the fish at a size and time similar to naturally produced wild Colorado pikeminnow in the San Juan River. In the upper Colorado River Basin, Colorado pikeminnow spawn on the descending limb of the hydrograph in June and July as water temperatures rise to 18°C (Haynes et al. 1984, Nesler 1988, Osmundson et al. 1995, Bestgen et al. 1998). This schedule would result in fish in the San Juan spawning in July in most years. Spawning dates back-calculated from age-length relationships of Colorado pikeminnow larvae collected in the San Juan from 1992-1996 resulted in spawning dates of July 8 - August 9 (Platania et al. 2000). As a rough estimate, fish spawned in mid-July should be 15-20 mm in mid-August, 20-30 mm by mid-September, and 35-45 mm by mid-October.

However, the fish actually stocked were somewhat larger than what would naturally

occur, due to the location of the source of the stocked fish. Dexter National Fish Hatchery (NFH) is located in southern New Mexico and sustains warm temperatures early in the year, inducing earlier spawning than what occurs in the San Juan River. Other delays in the stocking approval process resulted in stocking sizes of 55 mm on November 4, 1996; 45 mm on August 15, 1997, and 24 mm on July 2, 1998, all of which were about 10-20 mm larger than naturally reproduced fish should be. All of the pikeminnow were stocked at sizes larger than those normally collected in the drift, and were immediately ready to enter and remain in backwater habitats.

Drift by larval Colorado pikeminnow has been documented in the Yampa, Green and Colorado rivers (Nesler et al. 1988, Valdez et al. 1985, Bestgen et al. 1998). Larval Colorado pikeminnow are found in the drift up to 11-12 mm, and usually collected in backwaters thereafter (Trammell and Chart 1999, Anderson 1999). Following hatch, larvae emerge from the substrate, become entrained in the current and are transported to low-gradient nursery habitat areas which may be located substantial distances downstream. The mechanism by which drifting larvae locate, enter, and are retained by backwater habitats is not well understood, but seems to be a function of size of larvae, availability of habitats, and current speed.

On the Green and Colorado rivers wild spawned Colorado pikeminnow often drift long distances downstream from spawning areas to nursery habitat areas. For example, the lowermost spawning area in the Green River is located near RM 160, while the highest concentrations of age 0 Colorado squawfish below the spawning area are found from RM 120-0; a distance of 40-160 miles below the spawning site (Muth et al. 2000). Some age 0 pikeminnow are collected above the concentration areas, but they may be products of an upstream spawning site in the Yampa River.

The only suspected spawning site on the San Juan River is at RM 131. Drifting long distances in the San Juan River from this location would deliver them into the lower river, or into Lake Powell. In fact, 19 of 21 wild age 0 pikeminnow collected in the San Juan River since 1991 have been collected in the Lower San Juan. If larvae are produced at this location by the stocked fish, when mature, or by wild fish, they would presumably drift to the Lower San Juan, where it has been shown they are unlikely to be retained, except in the lowermost 13 miles of river (Archer et al. 2000). These 13 miles of nursery habitat may not be adequate to support enough recruitment to sustain a reproducing population of Colorado pikeminnow. Typically, nursery habitat areas for Colorado pikeminnow in other rivers are much longer. The four standardized nursery habitat reaches in the upper Colorado River Basin's Interagency Standardized Monitoring Program, which are based on historic concentrations of age 0 Colorado pikeminnow, include the lower 120 miles of the Green River, 119 miles in the middle Green River near Ouray, UT, the lower 110 miles of the Colorado River above it's confluence with the Green River, and 30 miles on the Colorado River near Grand Junction, CO (USFWS 1987).

The question remained if wild spawned fish or fish stocked as larvae, would be retained in the San Juan River, or if they would drift past all nursery habitat into Lake Powell. It was desirable to stock Colorado pikeminnow as larvae to attempt to answer this question. In 1999, spawning was successfully delayed at Dexter NFH until the first of July. The fish were stocked as swim-up larvae, 5 days post-hatch at approximately 7-9mm, on July 7. This date and size closely approximated a natural spawning event. This report evaluates that stocking event.

METHODS

Study Area

Nursery habitats were sampled from RM 158.0 to 3.0 at the rate of 2 habitats/mile beginning just below the stocking site at RM 160.0. In addition, four nursery habitat sections were sampled more intensively. Beginning with the most upstream section, and progressing downstream, they were designated as Section 4 (RM 131.0-126.0), Section 3 (RM 89.0-84.0), Section 2 (RM 25.2-20.2) and Section 1 (RM 13.0-8.0). Each nursery habitat section is contained within a larger Geomorphic Reach, as defined by the SJRIP and described in numerous reports, such as Archer et al. (2000). Nursery habitat Sections 1-3 correspond to Geomorphic Reaches 1-3, while Section 4 straddles the geomorphic Reaches 4 and 5. Each section differs in basic geomorphology which affects habitat formation and availability, as described in Archer et al. (2000). However, sections 1 and 2 are relatively similar, as are sections 3 and 4. For some of the analysis, the study area was divided into the upper San Juan, from RM 158 to 53 which includes nursery habitat sections 3 and 4, and the Lower San Juan which includes nursery habitat sections 1 and 2.

Stocking and Cudei Diversion Entrainment

Approximately 500,000 Colorado pikeminnow larvae were stocked below the hogback diversion. All fish were provided by the Dexter National Fish Hatchery (New Mexico). Several million artificial 'eggs' were released simultaneously to mimic passively drifting larvae (Dudley and Platania 1999, Dudley and Platania 2000). Approximately 18 miles below the stock site, the Cudei diversion blocks a large portion of the river, diverting the flow into a canal. Most of the flow returns immediately to the river through a headgate system, but about 5-15 cfs (visually estimated) is further diverted into an irrigation canal. To evaluate the entrainment of stocked pikeminnow in the canal, a Moore Egg Collector (MEC) was set in the irrigation canal immediately following stocking. Use of the MEC for collection of drifting larvae and eggs is detailed in Altenback et al. (2000). Drifting larvae and artificial eggs were collected from the MEC in 15 minute intervals, preserved in ethanol, and identified and enumerated by University of New Mexico (UNM). Data were provided to the Utah Division of Wildlife (UDWR).

Nursery Habitat Sampling

In the San Juan River, nursery habitats and fish were sampled at two levels of intensity. From RM 158 to 3, two habitats per each 5 miles were sampled. In addition, every potential nursery habitat was sampled in each of the four nursery habitat sections. Sampling procedures were similar to those used for nursery habitat studies conducted on the Green and Colorado rivers (Trammell and Chart 1999, Trammell et al. 1999), and are described in Archer et al. (2000). Fish were collected by seining with 1 to 4 seine hauls per habitat, depending on the size of the habitat. Two seine sizes were used: 4m x 1m x 1.6mm mesh, and 1m x 1m x 0.5m mesh. The smaller seine was only used on the first sampling trip. Length, width and depth of each area seined was recorded. Catch rates were computed as #fish/100m^2. Backwater habitats were classified to a type based on the geomorphic and hydrologic processes which formed them. A table of these

habitat types is presented in Archer et al. (2000).

Physical habitat measurements were collected at three transects: the mouth, 1/3, and 2/3 of the longitudinal length of the habitat. Depth measurements were taken at the point of maximum depth and ½ the distance either way along each transect. Both water depth and water-plus-substrate depth were measured. At each depth measurement, primary and secondary substrate particle sizes were estimated and recorded. Surface temperature was recorded (^{0}C) at the midpoint of each transect.

All native fish identified in the field were measured and released.. Non-native fishes were recorded as either sub-adult or adult or preserved in 10% formalin for later identification. Fish density (fish/100 m^2) was computed for all species. All preserved fishes were identified and counted at the UDWR Moab field office laboratory. Samples were then sent to the University of New Mexico for verification and curation in the Museum of Southwestern Biology.

RESULTS

Discharge

Annual

Spring runoff discharge (Q) as measured by the USGS gage at Bluff (#093795000) peaked on June 3, 2000 at 7429 cfs (maximum daily mean). Several rain-generated flood events resulted in secondary peaks - some greater than the spring peak in July, August and September (Figure 1). Flows during the sampling trips ranged from 7550 cfs in August to 716 cfs in October. Although late summer monsoons commonly result in flash floods in the San Juan, in 1999 flows throughout the summer and fall were higher and more variable than usual. The high flows were a result of high tributary inflow related to rain, and increased reservoir releases also due to rain. Stable flows of <1000 cfs were not reached until late October.

Stocking

Stocking occurred on July 7, and subsequent drift sampling was conducted from July 7-12, 2000. On July 7, 2000, daily mean discharge (Q), as measured by the Shiprock gage (USGS # 09368000) was 2750 cfs, rising to 4770 on July 10. Daily mean discharge from July 7 to July 12 is shown in Figure 2. Discharge at the Shiprock gage was similar to the Bluff gage, with changes in flow occurring approximately 1 day earlier at the Shiprock gage. The gages are 90 miles apart, and at a current velocity of 3.8 miles/hour (CBRFC 1997), are 23.6 hours apart.

Daily flows at Bluff in 15 minute increments for July 7-12 are shown in Figure 3, with number of larvae collected in 15 minute increments for the three sites where larvae were collected. In the 5 days following stocking, rain storms caused the flows to cycle rapidly between 2000 and 4000 cfs several times, at one point reaching a peak of 6020 cfs. This peak was recorded at Bluff on July 10 at 1945 hours, and would have passed Shiprock 24 hours earlier. This rapid series of flow changes would cause nursery habitats to be unavailable, or unstable at best.

Cudei Diversion entrainment

Approximately 500,000 larval Colorado pikeminnow were stocked on July 7, 2000, at 2030 hours. The MEC was operated continuously in the irrigation canal from 2230 hours to July 8, 2345 hours. Sampling was discontinued from 0000 to 0630 hours due to lightning and rising water. Sampling resumed at 0630, July 8, and continued until 2000 hours when lightning and swiftly rising water again occasioned a break in sampling. The canal was quickly blocked by flood debris, cutting all flow to the canal, so sampling was ended. Drifting larval pikeminnow were collected at several other sites along the San Juan River to evaluate transport velocity. Those results were reported by Dudley and Platania (2000), and were provided to UDWR as well, and are shown in Figure 3.

Larval pikeminnow were collected in the Cudei irrigation canal on July 8, from 0215 hours to 0830 hours. The first fish was collected 4.75 hours post stocking and the last was collected 11 hours post stocking, with the peak in collection from 0315 to 0400 hours, or about 6.5 hours post stocking. Continuous sampling completely bracketed all larval collections, continuing for 16.25 hours after the last fish was collected, so we are confident that none were missed during the break in sampling. Table 1 summarizes the stocking and subsequent larval collections.

Fish were first collected at Shiprock 1.75 hours before Cudei. The sites are 6 miles apart, which indicates the fish were traveling at 3.4 mph. The catch rate of pikeminnow at Shiprock was 8.15 fish/100m^3 (from first to last fish only). The catch rate in the Cudei canal was 4.39 fish/100m^3. Some longitudinal decrease in catch rates was expected, but a 43% decrease in 6 miles is greater than expected, compared to catch rates at Clay Hills, 140 miles downstream, which had declined 80% from Shiprock. Inexplicably, no larvae were collected at the Mexican Hat site, between Cudei and Clay Hills.

The decrease in catch rates between Shiprock and Cudei indicate that proportionately fewer larvae were entrained than flow was diverted. The flow in the Cudei canal was visually estimated at 15 cfs, or 0.5% of the total river. The Shiprock site produced 183 larvae in two MECs run concurrently, or approximately 0.037 % of the total stocked. At Cudei, a total of 63 larvae were collected, which is approximately 0.013 % of the total number stocked. The percent sampled of the total river volume was calculated by dividing the total volume sampled by the total estimated river volume. Total river volume was calculated by multiplying the 15 minute increments of discharge in cfs, by the total number of seconds sampled from first to last fish collected, resulting in 0.177% sampled at Shiprock, and 0.018% at Cudei (Table 2). The percent of the river sampled was greater than the percent of stocked fish collected, but the ratio between the two percents declined only slightly between Shiprock and Cudei, and remained similar between Cudei and Clay Hills.

Table 1. Summary of Colorado pikeminnow (PTYLUC) larvae stocked at Hogback, San Juan River, July 7, 2000, and subsequent drift collections. (Data provided by UNM - Steve Platania)

Site	PTYLUC	RM	Sampling period	First fish - Hours post stock	Last fish - Hours post stock	Speed (mph) from stock to site	CPUE fish/100m^3
STOCK	500,000	160	-	-	-	-	-
Shiprock	183	148	25.75	3	9	3.0	8.15
Cudei	63	142	31.75	4.75	11	3.1	4.39
Mex. Hat	0	53	60.25	0	0	-	0
Clay Hills	14	3	63.5	62	71.75	2.5	1.63

Table 2. Total volume sampled, total river volume and % sampled, calculated from collection of first to last fish, of Colorado pikeminnow stocked at Hogback, July 7, 2000 .

Site	PTYLUC	Hours with fish	Total ft^3 sampled	Total ft^3 in river	% of river sampled	% of stocked fish collected
Shiprock	183	5	79271.6	44784000	0.177	0.037
Cudei	63	6.25	50719.4	61074000	0.083	0.013
Mex. Hat	0	0	-	-	-	-
Clay Hills	14	9.75	30303.8	165564000	0.018	0.003

Nursery habitat sampling and habitat availability

Three river-long sampling trips were conducted after the fish were stocked. The first trip began on July 27, three weeks post stocking. In both the nursery habitat sections and the river-wide sampling, a total of 79 habitats were sampled, with a total area of 4,620.6 m^2 seined, with both 1.6 mm mesh and 0.8 mm mesh seines. None of the stocked fish were collected, and only 1,829 other fish were collected. The most habitat available was in nursery habitat (NH) section 3 (RM 89-85) which contained 18 habitats with 8,973.7 m^2 of habitat, mostly in secondary channels with very low velocity flow. However, this habitat was unstable, due to the rapidly changing flows. The July trip was cut short due to an accident, and the final 25 miles of river, including the lower two nursery habitat sections, were not sampled. A visual survey of the final 25 miles a few days later observed only 2 low velocity flooded tributary habitats. Most tributaries were flowing due to recent rains. Main channel habitats were completely inundated

due to high flows (3560 cfs).

The next trip was conducted from August 31 - September 3. Again no Colorado pikeminnow were collected. A total of 67 habitats were sampled with 6,543.5 m^2 seined in river-wide and nursery habitat sections. Flows increased before and during this trip to 7550 cfs, which is higher than any previously sampled flows from 1994 to 1998 (Archer et al. 2000). NH section 1 contained the largest amount of available habitat (8,956.5 m^2). However, again the rapidly changing flows throughout the summer meant the habitats were unstable.

The final trip was conducted from October 25-28. Flows stabilized under 1000 cfs just before the trip. Again, no Colorado pikeminnow were collected. A total of 100 habitats were sampled with 12,873 m^2 seined. Again, NH section 1 contained the most habitat (10,595.8 m^2), although the flow was only 812 cfs, compared to 7070 cfs on the previous trip. After the first three sampling trips produced no stocked fish, the remaining three sampling trips were canceled in hopes of repeating the experiment next year.

Total nursery habitat availability in area was evaluated from the four nursery habitat reaches, wherein all habitats were measured and sampled. Total area of habitat was compared between reaches (Table 3). For further comparison, Tables 4 and 5 summarize nursery habitat availability for August and September, 1994 - 1999. Although habitat availability was comparable to previous years of study, the constant large changes in flows throughout the summer and fall meant that individual habitats were ephemeral and unstable - inundated one day and desiccated the next. This instability in flows and habitats may have contributed to the absence of stocked Colorado pikeminnow in our collections. Catch rates of all other species were low as well, compared to catch rates from 1991 to 1999 (Table 6).

Table 3. Number and area of available habitat in nursery habitat sections 1-4, for three sampling trips post stocking of larval Colorado pikeminnow, 1999.

	NH SECTION 4	NH SECTION 3	NH SECTION 2	NH SECTION 1
July/August				
Discharge (Q)	3070	2680	2940	2670
Number of habs	9	18	-	-
Area of habs (m^2)	3376.3	8973.7	-	-
August/September				
Discharge (Q)	6560	5330	7550	7070
Number of habs	3	3	6	15
Area of habs (m^2)	3340	4703.3	1470.7	8956.5
October				
Discharge (Q)	716	828	838	812
Number of habs	4	3	17	27

Area of habs (m^2)	3396.3	3300	1914.4	10595.8

Table 4. Total number and area of nursery habitats and discharge at time of sampling (Q in cfs) in Nursery Habitat section 1-4 on the San Juan River, August 1994-1999.

	NH SECTION 4	NH SECTION 3	NH SECTION 2	NH SECTION 1
1994				
Q NUMBER AREA	NA	646 21 2960	546 18 2136	439 36 13258
1995				
Q NUMBER AREA	1390 46 6248	1240 22 2947	1240 23 2156	1470 14 4964
1996				
Q NUMBER AREA	210 29 3443	262 27 3948	262 28 2337	317 52 13933
1997				
Q NUMBER AREA	3050 14 2421	3110 12 5664	2780 8 1236	2320 37 15163
1998				
Q NUMBER AREA	535 9 2664	613 9 2002	535 7 421	613 19 6808
1999				
Q NUMBER AREA	3070 9 3376	2680 18 8974	2940 NA NA	2670 NA* NA

* Two habitats were observed but not sampled

Table 5. Total number and area of nursery habitats and discharge at time of sampling (Q in cfs) in Nursery Habitat section 1-4 on the San Juan River, September 1994-1999.

	NH SECTION 4	NH SECTION 3	NH SECTION 2	NH SECTION 1
1994				
Q NUMBER AREA	NA	1080 1 310	1040 5 1071	937 28 9308
1995				
Q NUMBER AREA	947 11 2483	947 11 1746	1010 18 1855	1190 20 4408
1996				
Q NUMBER AREA	1020 14 3716	914 11 2841	914 18 3035	870 30 9840
1997				
Q NUMBER AREA	3110 7 2323	3440 12 6412	3920 12 1664	5260 16 5141
1998				
Q NUMBER AREA	1070 8 5224	776 3 2248	947 11 1102	776 12 2200
1999				
Q NUMBER AREA	6560 3 3340	5330 3 4703	7550 6 1471	7070 15 8957

Growth / Survival

None of the stocked fish were collected after the initial drift sampling, so growth and dispersal could not be assessed. The absence of the stocked fish from our collections could be due to several factors. Primarily, we believe the numerous high-magnitude rain-generated flash floods that occurred soon after stocking contributed to a high degree of mortality, through loss or unavailability of habitat coupled with high velocity transport rates. At the most downstream collection site, Clay Hills, larvae were collected beginning 62 hours post stocking and ending 72 hours post stocking, although sampling continued for another 34 hours. This indicates that the larvae passed entirely out of the San Juan River in 3 days. During these three days, flows cycled between 2370 and 6020 cfs, with several separate peaks. Fewer fish were collected at Clay Hills than near the stocking site, and the catch rate was lower. The discrepancy could be attributed to mortality (through predation or other causes), or retention of the fish higher in the system. However, no fish were collected during UDWR sampling or during the standardized fall monitoring (David Propst, personal communication), therefore retention seems unlikely, and mortality probable.

Fish Community

All fish collected were identified to species and counted. Catch rates for the more common native and non-native species are given in Table 6. This table is a continuation of catch data for the August and September sampling trips from 1991-1999. Catch rates of non-natives were the lowest encountered in the 9 years of study, and catch rates of native species were also very low in 1999. There were virtually no native suckers produced. The 1.13 fish/100m^3 for flannelmouth sucker (*Catostomus latipinnis*) in August is actually of the previous year class of fish. Other native species collected were bluehead sucker (*Catostomus discobolus*), speckled dace (*Rhinichthys osculus*), and occasionally roundtail chub (*Gila robusta*). Nonnative species were primarily the red shiner (*Cyprinella lutrensis*) and fathead minnow *(Pimephales promelas)*, which collectively made up 66 to 99% of the total catch. The next most common non-native was channel catfish (*Ictalurus punctatus*), which on occasion made up as much as 2.3% of the total catch. Other non-native species included mosquitofish (*Gambusia affinis*), plains killifish (*Fundulus zebrinus*), largemouth bass (*Micropterus salmoides*), Green sunfish (*Lepomis cyanellus*) and threadfin shad *(Dorosoma petenense),*.

For 1998 and 1999, the catch rates were further divided into the upper and lower San Juan (Tables 7 and 8). There was usually a higher proportion of natives in the upper section, and a correspondingly higher proportion of non-natives in the lower section. Almost all the native speckled dace were collected in the upper section. On the final trip in 1999, a large increase of non-natives, particularly red shiner, was observed. Almost all of these fish were collected in the last two miles of the river, and half were collected in the final backwater habitat. The extended and variable high flows appeared to negatively affect the numbers of all fish species, both native and non-native.

Table 6. Catch rates (number/100m^2) of native and non-native fish and percent composition for August and September, 1991-1999 . Headers are: Bluehead sucker (CATDIS), Flannelmouth sucker (CATLAT), Speckled dace (RHIOSC), Red shiner (CYPLUT), Fathead minnow (PIMPRO), Percent non-native (including incidental catch of other non-native species) (%NON) and Percent native (%NATIVE).

YEAR	CATDIS	CATLAT	RHIOSC	CYPLUT	PIMPRO	%NON	%NATIVE
				AUGUST			
1991	62.9	51	46	298	204	76	24
1992	48	40	37	51	147	89	11
1993	154	14.5	118	882	272	80	20
1994	47	6	41.6	138	21	64.3	35.7
1995	200	0.9	86	51.7	2.9	18	82
1996	0.15	0	0.45	81.9	10	99.4	0.6
1997	6.4	8	55.1	75	34.4	73.4	26.6
1998	0	0.11	2.8	45.6	3.2	90.5	9.5
1999	0	1.13	7.83	26.0	1.9	77.4	22.6
				SEPTEMBER			
1991	0.8	0.3	15.6	174	129	95	5
1992	2.9	2.9	30	104	117	86	14
1993	9.9	23.4	87.9	433	306	86	14
1994	8.7	1.9	239	1402	2389	94	6
1995	5.2	.5	25	73	65	84	16
1996	0	.03	1.5	275	337	99.998	.002
1997	0.12	0.3	13.7	50	7.9	80.4	19.6
1998	0	0.38	0.4	76.2	2.7	98.7	1.3
1999	0.02	0.09	1.97	19.1	9.8	93.5	6.5

Table 7. Catch rates in 1998, for selected species. Upper and lower San Juan River, for all sampling occasions. Headers are: Bluehead sucker (CATDIS), Flannelmouth sucker (CATLAT), Speckled dace (RHIOSC), Red shiner (CYPLUT), Fathead minnow (PIMPRO), Percent non-native (including incidental catch of other non-native species) (%NON) and Percent native (%NATIVE).

MONTH	CATDIS	CATLAT	RHIOSC	CYPLUT	PIMPRO	%NON	%NATIVE	TOTAL FISH
APRIL								
UPPER	0.03	0.04	0.9	25.6	2.1	94.8	5.2	2758
LOWER	0	0.02	0.1	26.5	0.8	97.3	2.6	1385
JULY								
UPPER	2.6	0.86	11.4	74.0	15.0	75.6	24.4	6069
LOWER	0.04	0.89	0.6	38.3	10.2	97.2	2.8	1754
AUGUST								
UPPER	0	0	4.3	50.0	8.8	86.9	13.1	4324
LOWER	0	0.3	0.04	37.1	4.0	99.3	0.7	2242
SEPTEMBER								
UPPER	0	0.38	0.4	76.2	2.7	98.7	1.3	1994
LOWER	0	0.44	0.5	74.6	0	98.1	1.9	1409
NOVEMBER								
UPPER	0	0.36	2.5	168.6	12.4	98.4	1.6	6634
LOWER	0	0.1	1.2	230.9	0.2	99.4	0.6	4671

Table 8. Catch rates in 1999, for selected species. Upper and lower San Juan River, for all sampling occasions. Headers are: Bluehead sucker (CATDIS), Flannelmouth sucker (CATLAT), Speckled dace (RHIOSC), Red shiner (CYPLUT), Fathead minnow (PIMPRO), Percent non-native (including incidental catch of other non-native species) (%NON) and Percent native (%NATIVE).

MONTH	CATDIS	CATLAT	RHIOSC	CYPLUT	PIMPRO	%NON	%NATIVE	TOTAL FISH
APRIL								
UPPER	0	0.06	0.08	78.2	2.8	99.8	0.2	3984
LOWER	0	0.03	0.17	152.3	5.8	99.9	0.1	4760
JULY/AUGUST								
UPPER	0	1.44	9.9	23.4	1.9	71.5	28.5	1432
LOWER	0	0	0.5	35.5	1.7	98.8	1.3	397
AUG/SEP								
UPPER	0.03	0.18	3.72	3.5	3.6	65.8	34.2	383
LOWER	0	0	0.16	35.3	16.2	99.7	0.3	1415
OCTOBER								
UPPER	0.4	0	0.1	3.6	0.66	96.9	3.1	364
LOWER	0	0	0.04	177.6	3.2	99.98	0.02	8430

DISCUSSION

It was difficult to determine if the number of larvae entrained in the canal were proportionate to the total number stocked, partly because there was no accurate measurement of flow diverted by the canal. We estimated that the canal diverted about 0.5 % of the flow on July 7 (15 out of 2750 cfs). For fish to be proportionately entrained, we assume that the fish are homogeneously distributed in the water column. However, the fish were not homogeneously distributed at Shiprock (12 miles below the stock site). When the total transport abundance was extrapolated from the catch rate for the total volume of the river, the result was 103,384 fish, considerably less than the 500,000 that were stocked. Also, the proportion of the total river volume sampled was higher than the proportion of stocked fish collected, even at the most upstream site, therefore fish were not collected proportionately to the flow in the main channel, or in the diversion canal. However, comparing the relative catch rates at Shiprock and at Cudei suggests that proportionately fewer larvae were entrained in the canal. The catch rate of pikeminnow at Shiprock was 8.15 fish/100m^3 (from first to last fish only), and the catch rate in the Cudei canal was 4.38 fish/100m^3.

The information gathered from the drift portion of this study indicates that drifting larvae can be quickly transported out of the river system and into Lake Powell. The reduction in the number and catch rates of larvae collected between Shiprock and Clay Hills indicates that some larvae are either retained higher in the system, lost through mortality, or both. No stocked pikeminnow were collected during the subsequent river-wide sampling trips, or during the fall standardized monitoring trip. The absence of pikeminnow in all of the collections suggests that few, if any, larvae were retained in the river. Therefore, it seems that mortality is more likely. Mortality of the larvae could have been effected by predation, or through other environmental factors.

The Colorado pikeminnow stocked from 1996 to 1998 showed excellent growth, survival and retention in the San Juan River. The stocking of larval pikeminnow in 1999 was intended to determine if larval Colorado pikeminnow, stocked or spawned above the suspected spawning site at RM 131, could be retained in the San Juan River, or if their natural tendency to drift coupled with the relatively high gradient and water velocity would transport them past all available nursery habitat and into Lake Powell. The absence of the stocked pikeminnow in subsequent nursery habitat sampling suggests that larvae are unlikely to be retained in the system. However, the several strong spates, occurring so soon after the fish were stocked, resulted in unusually difficult conditions for the larvae. The total amount of nursery habitat available immediately after stocking was comparable to other years, but the rapidly changing flows meant that individual habitats were probably ephemeral. The majority of the habitats closest to the stocking site are secondary channels which are very sensitive to changes in flow. Changes in flow of the magnitude witnessed from July 7 to 10 could alternately inundate, scour and desicate many habitats. Under conditions of more stable flow immediately following stocking, there might be a greater possibility that the larvae could be retained in the river, upstream of Lake Powell. The original study plan called for 6 post-stocking sampling trips. After the third trip with no pikeminnow collected, the decision was made to cancel the remaining trips and repeat the experimental stocking of larvae in 2000.

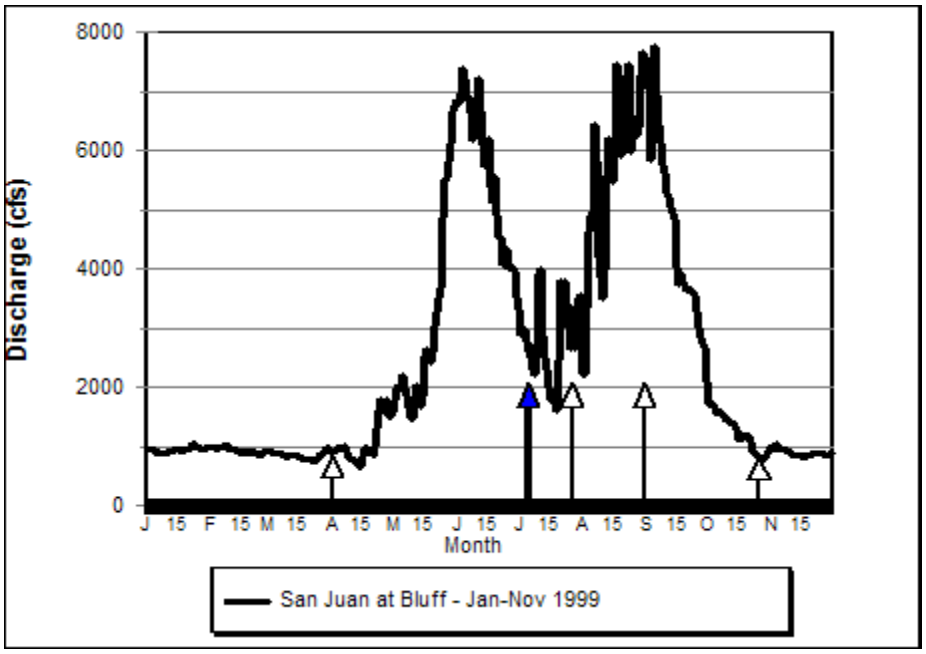

Figure 1. San Juan River daily mean discharge from January to November, 1999, as measured at the USGS gage at Bluff (#09379500). Open arrows indicate trip dates. Solid arrow indicate s stocking date.

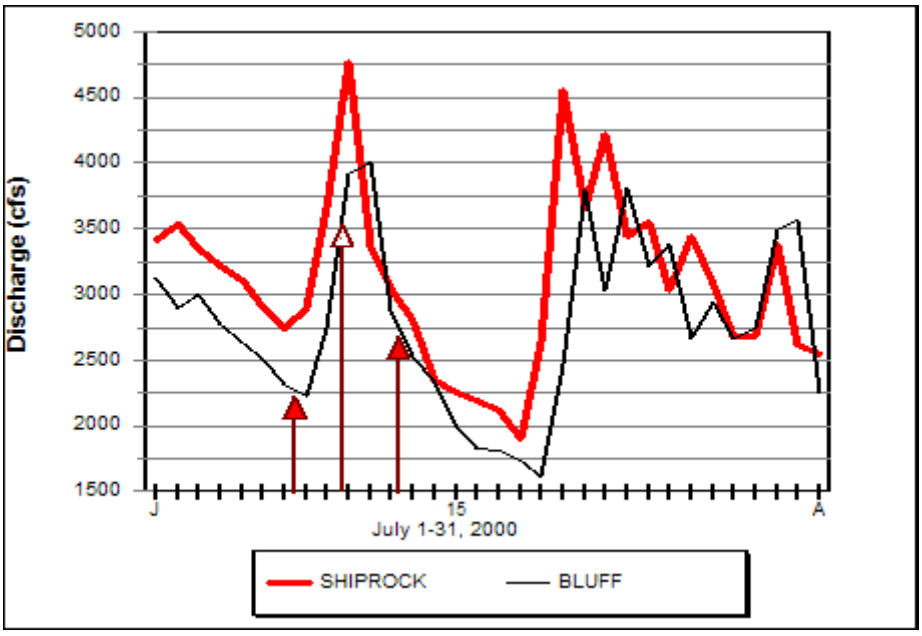

Figure 2. San Juan River daily mean discharge from July 1 to July 31, at the USGS gage at Bluff (#09379500). First arrow is stocking time on July 7, second arrow is end of sampling at Cudei, third arrow is end of sampling at Clay Hills.

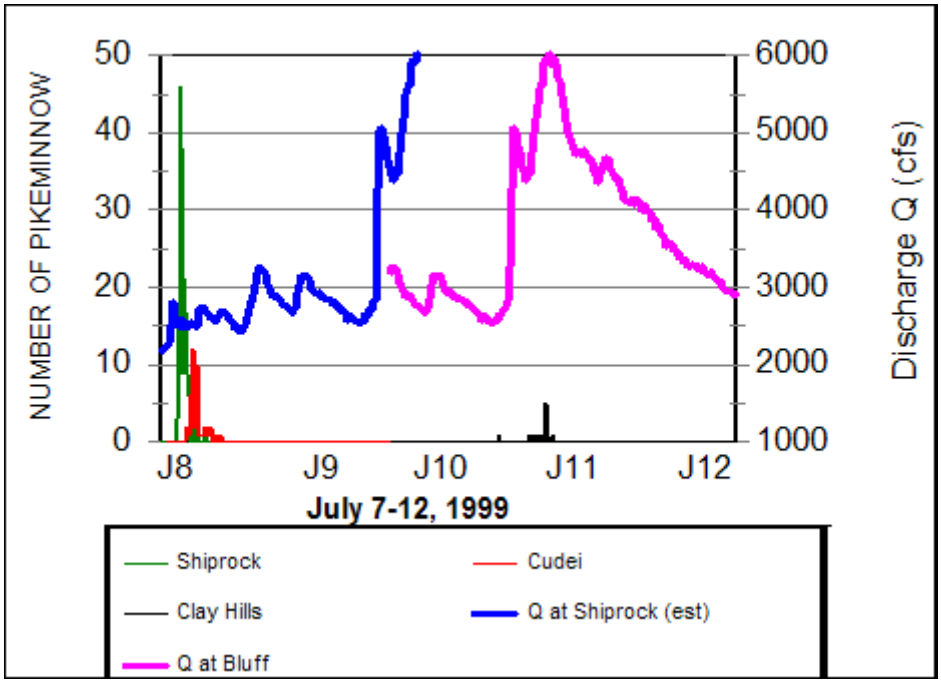

Figure 3. Collection of Colorado pikeminnow larvae and discharge in 15 minute increments, July 7-12, 1999. Discharge at Shiprock was estimated from Bluff gage (#09379500) data, as occurring 24 hours earlier at Shiprock.

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